[illegible] TRANSMISSION vs. [illegible]

Case I.

Transmission Method

w_T = Width of film in inches

l_T = Length of film in inches

With N black lines/mm in each direction

Number of Lines in l_T direction = $N l_T \times 25.4$

Number of Lines in w_T direction = $N w_T \times 25.4$

t = Time in seconds for one scan line = $N l_T \cdot 25.4 / f_{\mu}$

f_{μ} = highest frequency transmitted = [illegible] = bandwidth

T_f = Time to transmit one frame = N [illegible] $\cdot 25.4$

ϕ = Factor greater 1 to indicate excess of scan lines to transmit N lines

So T_f

$$T_f = \frac{N w_T \cdot 25.4 \cdot N l_T \cdot 25.4 \, \phi}{f_{\mu}}$$

ϕ is a number between 2 & 3 and comes about because the detail is positioned arbitrarily with respect to the scan lines

3 [illegible]

$$T_f = \frac{(25.4)^2 \times 2\, N^2\, W_T\, l_T}{\Delta f}$$

$$\boxed{T_f = \frac{1955\, N^2}{\Delta f}\, W_T\, l_T} \quad (1)$$

or

$$\boxed{l_T = \frac{T_f\, \Delta f}{1955\, N^2\, W_T}} \quad \text{inches}$$

T_f = Frame time in seconds

Δf = in cycles/seconds

W_T = in inches

N = lines/mm

[illegible]

with T_c, in Minutes [illegible]

[illegible] tells the [illegible] recorded in [illegible] time) [illegible]

[illegible] channel [illegible]

[illegible]

[illegible] Reporter

[illegible] of a [illegible]

Orbital Period Approx. [illegible]

$T =$ [illegible]

[illegible]

V_e = Velocity over the earth

$$V_e = [illegible]\ 2.62 \times 10^{[illegible]}\ [illegible]\ h)^{-3/2}$$

For h in Miles

$$V_e = 2.[illegible] \times 10^{4} \left(1 + [illegible] \frac{h}{[illegible]}\right)^{-1/2} \text{ ft/sec}$$

Now the velocity of a point on the image

$$V_i = \frac{V_e\, f}{h} \text{ ft/sec} \qquad f = \text{focal length in Miles}$$

$$V_i = \frac{V_e\, f}{12 \times 6000\, h} \text{ ft/sec} \qquad f \text{ in inches}$$

$$V_i = \frac{V_e\, f}{6000\, h} \text{ in/sec} = \frac{V_e\, f}{100\, h} \text{ in/Min}$$

l_f = length of recovered film = $\frac{V_e\, f\, T_{[illegible]}}{100\, h}$ [illegible]

$$l_R = \frac{2.12 \times 10^{2} \left[1 + \frac{h}{4000}\right]^{3/2} f \; T_f}{h} \quad \text{Inches}$$

h in Miles

f in Inches

T_f in Min.

Gain $= \dfrac{l_R}{l_T}$ when ≥ 1 Received Better

when < 1 Transmitted Better

$$G = \frac{2.12 \times 10^{2} f \; T_f \; 10^{2} \; N^{2} \; W_T}{\left[1 + \frac{h}{4000}\right]^{3/2} h \; 5.1 \; T_f \; \Delta f} \; Q^{2}$$

where Q indicates losses in reproducing the transmitted image. (A number between 2 & 5)

$$G = \frac{8450 \, f \, N^{2} \, W_T \, Q^{2}}{h \, \Delta f \left[1 + \frac{h}{4000}\right]^{3/2}}$$

f in Inches

N in [illegible]/mm

W_T in Inches

h in Miles

Δf in cycles/sec

... Lines/mm

$\Delta f = 6 \times 10^6$ $n = 200$

$$\frac{\ldots \times 10 \ldots}{200 \times 6 \times 10^6 \; 1.076}$$

$$= \frac{1.95 \times 6}{20 \times 1.076} W_T \, Q^2 = \ldots W_T \, Q^2$$

Conservatively $Q = 2$

$Q = 2$ is more conservative (that is favors [illegible] more) than Buchheim P 222 Space Handbook.

$G = 9.4\, W_T$

Recovered systems very conservatively recover [illegible] the info

[illegible] must be stressed that recovered systems are the only [illegible] [illegible] geometry. There is no comparison. Scanning system [illegible] linearity are unsuited for long measurement problems. The above analysis is limited to resolution and information content.

The last point - recovered film resolution is limited by lens, [illegible] processing etc, but not scanning and transmission and reproduction degradation. These effects are all taken into Q,

Q [illegible] between 2 to 5

So the gains given are the smallest, smallest, possible.

Now consider the time a transmitter is in sight of a receiver with reasonable signal to noise ratio. For approximately 90 min. orbit, 16 passes/day, transmitter in contact 4 min/pass

(At least 3 stations to get this average amount)

Reasonable transmission time in 24 hours is 64 Min. [illegible] If you recover at 24 hrs. satellite it will have seen [illegible] daylight.

Gain of approx. 10.

Apply this to Gain fig. on page 6, we get gains for the various film widths of 260 to 850 times.

When recovering 5" Film

gains as high as 400 are reasonable

When recovery 9" Film

gains as high as 250 are reasonable.

It is generally said that recovery and readout [illegible] about [illegible] to realize. This is the BMD position, for example. We feel recovery is easier and since it gives much more information and [illegible] recovered records, we feel it should be specified in all systems [illegible] where the information perishes in a few hours. Even then it is not clear that this highly perishable information can be detected by this system. If it can, then consideration should also be given to "once over" [illegible] vehicles since this is maximum information in [illegible] time.

TELEMETRY vs. RECOVERY

The E-2 system, operating at its maximum capacity every day for its entire 90 day lifetime and subject to no lost or wasted film and no transmission jamming will give an area coverage of about 3.56 million square miles over the Sino-Soviet area. At the scale of about 1/480,000 as presently considered, this is equivalent to less than 30 pounds of thin base film.

The coverage is not limited by the data gathering ability of the camera but rather by the readout time required by the telemetry system and the total lifetime of the vehicle. If a recovery system is considered, the same camera can obtain the same coverage in only 10 days, or conversely could obtain 9 times the amount of coverage in the same 90 days. Also, if alternate cameras are considered, the data gathering time could be further shortened or the scale enhanced or both.

The amount of film which could be safely considered in a recovery system would be roughly 30 times the 30 pound equivalent now in the vehicle.

Thus, both total coverage and scale could be vastly improved with a recovery system, to say nothing of the improved reliability of a shorter lifetime satellite.

Comparison Table

	Telemetry	Recovery
Area Coverage	42,900 square miles/day	380,000 Square Miles/[illegible]
Linear Coverage	2520 statute Miles/day	22,400 Statute Miles/[illegible]
Time of Operation	90 days	10 days
Frame/day (.8 x 17 SM)	3150	28,000
Total Coverage	3.86×10^6 Square Miles	3.86×10^6 Square Miles
Film Weight	30 pounds	30 pounds

Recovery can carry greater film weight than 30 pounds, therefore, for completeness

Film Weight		110 pounds
Coverage		Total of 10 million Square Miles
Time		35 Days

The latter part of the comparison table shows that with only 110 pounds of film, a recoverable satellite could [illegible] complete coverage of the Soviet Union and China.

Thus, consideration of telemetry [illegible] for return of photographic data from space vehicles leads one [illegible] channel is not sufficient [illegible] as it can be [illegible]. Using very wide band data links to [illegible] possible solution, [illegible]

[illegible] transmitter power ins[illegible] [illegible] the problems of Doppler correction became [illegible] In very [illegible] transmission links, the relative frequency [illegible] components at one end of the sideband spectrum will be substantially different [illegible] the other end. This would have the effect of degrading the quality of intelligence being transmitted. Suitable corrections would have to be made, either at the sending end, or at the receiving end if quality is to be restored. The problem then centers about the ability of the receiving terminal to determine the relative velocity of the vehicle. [illegible] of [illegible] changes in velocity due to the different looking angles [illegible] for adding or subtracting frequency [illegible] proportional to the Doppler shift.

Other approaches to increasing the communication rate without increasing the bandwidth have been proposed. Methods such as velocity [illegible] modulation, dot arresting, level slicing and digitizing have all been proposed but none of them has ever proven practical.

The other problems which are normally considered in the communications business such as phase distortion, multipath effects and noise should also enter into any comparison discussion. All of the above, along with the redundancy [illegible], will have a [illegible] effect on the final data and must be considered.